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LONGITUDINAL SHAFT

The invention relates to a longitudinal shaft, particularly for use in automobiles having all-wheel drive or rear-wheel drive, comprising a gearbox-side articulation, a differential-side articulation, and a central articulation, each of which have an inner hub and an outer hub that surrounds the former at least in some regions, whereby two shaft segments are connected with one another so as to rotate together, by way of the central articulation. In this connection, the terms "gearbox-side" and "differential-side" are used merely as examples in the sense of this invention, to differentiate the two ends of the longitudinal shaft.

In the case of automobiles, which usually have a motor with a transmission, installed in the front in the direction of travel, the drive torque of the engine is transferred to the rear axle differential for rear-wheel drive, by way of a longitudinal shaft disposed in the direction of travel. In this connection, the longitudinal shaft is subjected to stresses that are as high as ten times the rated torque, as the result of frequently changing torques and speeds of rotation, as well as load shocks. At the same time, the vibrations and noises produced by the longitudinal shaft are supposed to be kept as low as possible.

Usually, a longitudinal shaft of the type stated initially is attached to the transmission output shaft and the differential input shaft, respectively, by way of a flange connection with the outer rings of the gearbox-side articulation and of the differential-side articulation. This flange connection simultaneously serves to center the longitudinal shaft. However, in the case of the high speeds of rotation of the longitudinal shaft that frequently occur during operation, between 8,000 and 10,000 revolutions per minute, even slight balance errors of the longitudinal shaft resulting from insufficient centering will bring about great centripetal forces in the longitudinal shaft, which result in vibrations and disruptive noises.

It is therefore the task of the invention to make available a longitudinal shaft of the type stated initially, in which the centripetal forces that cause the vibrations and noises are reduced to the greatest possible extent.

This task is accomplished, according to the invention, in that the inner hubs of the gearbox-side articulation as well as of the differential-side articulation have a central bore provided with a plug-in tooth system, to connect the longitudinal shaft for

integral rotation, and to center it, on journals of a gearbox output shaft and a differential input shaft, respectively. In this connection, the invention is based on the idea that the centering diameter of a plug-in connection between the inner hub of the gearbox-side articulation and of the differential-side articulation with the gearbox output shaft and the differential input shaft, respectively, which diameter is clearly smaller as compared with flange centering, allows a significant reduction in the unbalance of the longitudinal shaft, at the same quality of tolerance. In this manner, the centripetal forces caused by the unbalance are also reduced, thereby increasing the comfort of the vehicle, by means of lower vibrations and noises of the drive train. The connection between the gearbox output shaft and the differential input shaft by means of the longitudinal shaft takes place, in this connection, in that the profiled inner hub of the gearbox-side articulation of the longitudinal shaft is set onto a correspondingly profiled journal of the gearbox output shaft, and the inner hub of the differential-side articulation is pushed onto a journal of the differential input shaft. In this manner, not only is a connection between the gearbox output shaft and the differential input shaft that permits integral rotation produced, but also centering of the longitudinal shaft is achieved.

The centering of the two segments of the longitudinal shaft by way of the central articulation can be improved if the central articulation also has an inner hub having a central bore that is provided with a plug-in tooth system, which accommodates a corresponding journal of a shaft segment of the longitudinal shaft for plug-in centering for integral rotation. Here, the connection between the two segments of the longitudinal shaft in the central articulation takes place in essentially the same manner as the connection of the gearbox output shaft and the differential input shaft to the longitudinal shaft.

In a further development of the idea of the invention, it is provided that the two shaft segments of the longitudinal shaft are configured as shaft tubes, and the outer hubs of the gearbox-side articulation, the differential-side articulation, and the central articulation are shaped sheet-metal parts directly connected with the shaft tubes. The greatest possible use of shaped sheet-metal parts in the articulations of the longitudinal shaft, which are connected directly to the longitudinal shaft tubes by way of a weld seam, for example, reduce the overall weight of the longitudinal shaft. Minimization of the weight of the longitudinal shaft also contributes to reducing the centripetal forces that occur, along with the improved centering.

In the gearbox-side articulation, as well as in the central articulation, only very slight angles of inclination usually occur during operation, so that the use of a synchronous articulation in the gearbox-side articulation or the central articulation of the longitudinal shaft would not result in any clear improvement of the synchronicity properties. In order to achieve optimal efficiency of the longitudinal shaft according to the invention, it is therefore preferred to implement the gearbox-side articulation and/or the central articulation as a sliding articulation.

If the gearbox-side articulation and the central articulation are configured as sliding articulations and have a common installation/displacement path, which corresponds at least to a length such that the gearbox output shaft or the differential input shaft projects into the inner hub of the gearbox-side articulation or the differential-side articulation, respectively, in operation, the longitudinal shaft according to the invention can be installed in particularly simple manner, between the gearbox output shaft and the differential input shaft.

Since the angles of inclination during operation of the differential-side articulation of the longitudinal shaft usually lie in a range that lies clearly above those of the gearbox-side articulation and the central articulation, it is preferred, in order to improve the synchronicity properties, to configure the differential-side articulation as a synchronous articulation.

According to a preferred embodiment of the invention, the gearbox side shaft segment of the longitudinal shaft has a diameter that differs from that of the differential-side shaft segment, in such manner that the two shaft segments can be pushed onto one another in the manner of a telescope. With this embodiment of the longitudinal shaft, it is avoided that the longitudinal shaft will bend out when compressed end to end, for example as the result of an accident, and penetrate into the passenger compartment of the vehicle. Instead, if in-line compression occurs, the two shaft segments of the longitudinal shaft will move into one another in the manner of a telescope, so that danger to the passengers in the passenger compartment of the vehicle, resulting from the longitudinal shaft, is reduced.

The invention will be explained in greater detail in the following on the basis of an exemplary embodiment, making reference to the drawing.

This shows:

Fig. 1 a longitudinal shaft according to the invention, in cross-section, and

Fig. 2 a detail view of the gearbox-side articulation.

The longitudinal shaft 1 shown in Fig. 1 has two shaft segments 2 and 3, configured as shaft tubes, which are connected with one another by means of a central articulation 4. The left end of the longitudinal shaft 1 in the figure is the gearbox side that is usually disposed at the front of a vehicle in the direction of travel, while the right end of the longitudinal shaft 1 in the figure faces a rear axle differential in the installed state.

The gearbox-side shaft segment 2 of the longitudinal shaft 1 ends, on its side facing away from the central articulation 4, in a gearbox-side articulation 5, while the second shaft segment 3 has a differential-side articulation 6 at its end facing away from the

central articulation 4. The shaft segments 2 and 3 are configured as sheet-metal tubes, whereby the tube that forms the gearbox-side shaft segment 2 of the longitudinal shaft 1 is connected with the outer hub 7 of the gearbox-side articulation 5, which hub is configured as a shaped sheet-metal part, by way of a weld seam 8, and is welded to a hollow shaft journal 9 on its side facing the central articulation 4. The tube that forms the differential-side shaft segment 3 of the longitudinal shaft 1 is connected with the outer hub 11 of the central articulation 4, or the outer hub 12 of the differential-side articulation 6, respectively, which are both configured as shaped sheet-metal parts, by way of weld seams 10a and 10b, respectively.

The outside diameter D_2 of the gearbox-side shaft segment 2 of the longitudinal shaft 1 is somewhat smaller than the inside diameter D_3 of the differential-side shaft segment 3 of the longitudinal shaft 1, so that the two shaft segments 2 and 3 can be pushed into one another in the manner of a telescope.

The gearbox-side articulation 5 as well as the central articulation 4 are sliding articulations, which have, from the outside to the inside, the outer hub 7 or 11, respectively, a cage 13, in which several balls 14 are guided, and an inner hub 15. In

this connection, the inner hub is provided with a central bore 16 that has a plug-in tooth system 17 for an integral rotation connection and centering with a correspondingly profiled journal.

On the outside of the inner hub 15 and the inside of the outer hub 7 or 11, ball raceways that run in the axial direction of the longitudinal shaft 1 are formed, in which the balls 14 guided by the cage 13 can roll or slide, in order to allow an axial displacement between the outer hub 7 or 12 and the inner hub 15. In this connection, as shown in Fig. 2, the cage 13 can be guided to be axially displaceable in the inner hub 15, or can have a cage guide in the outer hub (not shown).

The differential-side articulation 6 of the longitudinal shaft 1 is structured as a counter-path synchronous articulation having a profiled inner hub 18, a cage 20 that guides several balls 19, and the outer hub 12 provided with an insert 21. In this connection, a central bore 22 having a plug-in tooth system 23 for integral rotation accommodation and centering of a correspondingly profiled journal 24 of a differential input shaft is provided in the inner hub 18.

The journal 9 that is connected with the gearbox-side segment 2 of the longitudinal shaft 1 is elastically mounted by way of a ball bearing unit 25. Furthermore, the longitudinal shaft 1 is centered and mounted by means of the gearbox-side and differential-side articulations 5 and 6, respectively, in the inside hubs 15 and 18.

Installation of the longitudinal shaft 1 between the journal of a gearbox output shaft (not shown) and the journal 24 of a differential input shaft takes place, for example, in that first, the inside hub 15 of the gearbox-side articulation 5 is set onto the corresponding journal of the gearbox output shaft. The gearbox-side articulation 5 as well as the central articulation 4, which are both configured as sliding articulations, can be axially displaced from their center operating position of the balls 14, shown in Fig. 2, in both directions, by the length l_1, before the balls 14 reach the delimitation predetermined by the outer hub 7 or 11, which delimitations are indicated by the dot-dash lines 14a and 14b. In every sliding articulation, the inner hub can be deflected in both directions, by the length l_1, relative to the outer hub, from the position shown in Fig. 2, while the balls 14 are rolling.

In addition, the inner hub 15 can be displaced relative to the outer hub 7 or 11, by the length l_2, on the inner hub 15, while the balls 14 are rolling, when the balls rest against the delimitation stop 26 connected with the outer hub. In this connection, the maximal movement of the balls 14 on the inner hub 15 is limited by means of split rings 27.

The assembly displacement path of the gearbox-side articulation 5 as well as of the central articulation 4, which is composed of the lengths $l_1 + l_2$, in each instance, corresponds to at least half of the length L, with which the journal 24 of the differential input shaft projects into the inner hub 18 of the differential-side articulation 6 in operation. The longitudinal shaft 1 can thereby be pushed into itself, in the gearbox-side articulation 5 and the central articulation 4, to such an extent that the inner hub 18 of the differential-side articulation 6 can be oriented in alignment with the journal 24 of the differential input shaft. By means of displacing the inner hubs 15 relative to the outer hubs 7 and 11 in the gearbox-side articulation 5 and the central articulation 4, the inner hub 18 of the differential-side articulation 6 is pushed onto the journal 24 of the differential input shaft. When this is done, the longitudinal shaft 1 is simultaneously centered with the differential input shaft.

The articulations 4, 5, and 6 of the longitudinal shaft 1 can furthermore be sealed and protected against the penetration of dirt, by means of protective sheet metal pieces 28a, 28b, and 28c, as well as by means of folded bellows 29a, 29b, and 29c.